

**Hypothesis 13. Eye and Vision Research and the National Children's Study****Karla Zadnik, OD PhD****Glenn A. Fry Professor in Optometry and Physiological Optics****The Ohio State University College of Optometry**

The main eye problems affecting children from birth to high school, setting aside rare ocular diseases, are refractive error (myopia or nearsightedness; hyperopia or farsightedness; and astigmatism), strabismus (eye turn), and amblyopia (lazy eye). Amblyopia can result from undetected, uncorrected strabismus and/or from undetected/uncorrected refractive error. It results in a permanent loss of vision in an eye if the underlying condition is not cared for early on.

**Refractive Error****Refractive Error in Infancy**

The average cycloplegic refractive error for human infants at birth typically ranges from +1.00 D to +2.50 D with standard deviations on the order of 1.50D to 2.50D.<sup>1-6</sup> A process termed emmetropization then coordinates the development of optical power and axial length, resulting in distributions of refractive error at school age with mean values of +0.50 to +0.75D and standard deviations less than 1.00D (Figure 1).<sup>7,8</sup> Emmetropization can fail in some cases where the rate of reduction in hyperopia is too slow for the amount of hyperopia present. Refractive error is the result, meaning there is a mismatch between the eye's focal length and its axial length. In hyperopia, the typical refractive error of infancy, the eye's axial length is shorter than its focal length. The proportion of three-month-old infants with hyperopia  $\geq +3.50$ D in the Berkeley Infant Biometry (BIBS) Study is 16% (41/263 babies). Emmetropization occurs rapidly,<sup>6</sup> reducing this proportion to 3% by the age of nine months (7/244 babies). A large community-based screening sample in the UK put the prevalence of hyperopia  $\geq +3.50$ D in six- to eight-month-old infants at 6%.<sup>9</sup> Once the infant phase of emmetropization is complete between 9 and 18 months of age,<sup>6</sup> residual significant levels of hyperopia tend to persist, from infancy<sup>10</sup> through the school years. For example, the prevalence of clinically significant hyperopia  $\geq +2.00$ D in school-aged children is between 7.5% (unpublished data from the CLEERE Study) and 10%.<sup>11</sup> Longitudinal data from the CLEERE Study show that this level of hyperopia remains nearly constant between 6 and 14 years of age. Once past the age of emmetropization between 9 and 18 months of age, children show very little ability to "grow out of" their hyperopia. Myopia is also commonly albeit sporadically reported in newborns, with frequencies ranging from 0-25%. This myopia spontaneously resolves in infancy resulting in a low prevalence of myopia in early childhood of less than 2%.

A second source of myopia in infancy is prematurity. Dobson et al. (1981) found that the average refraction of 146 premature infants was -0.55D, much more myopic than expected for full-term newborns.<sup>12</sup> Grignolo (1968) studied both refractive error and ocular components in 58 full-term and 57 premature infants. Premature newborns had a mean refractive error of +0.50D, and were about -1.00D less hyperopic on average than full-term infants.<sup>13</sup> These differences diminish by the age of 6 months,<sup>13</sup> unless retinopathy of prematurity is present, in which case myopia of prematurity tends to persist.<sup>14</sup> Fledelius (1976) found that myopia over -6.00D was more common (1.1%) at age 8-13 years in 300 Danish children who had low birth weights (<2,000g) than in 237 children born at full-term (0.2%).<sup>15</sup>

A curious feature of infant refractive error is a high prevalence of refractive astigmatism oriented against-the-rule. Anywhere from 17%<sup>16</sup> to 63%<sup>17</sup> of infants may have astigmatism greater than 1.00DC. This astigmatism is transient. The prevalence of astigmatism  $\geq 1.00$ DC decreases rapidly during the first year of life, falling at 18 months to a level found in childhood of under 10%.<sup>18, 19</sup>

**Refractive Error in Childhood**

The prevalence of myopia remains low, under 2%, until about the age of 7 or 8 years, when there is a consistent rise in prevalence which only begins to level off in the early teens at 15 to 20% (Figure 2<sup>20</sup>). Risk factors for myopia include the influence of parental history and near work during childhood.<sup>21-23</sup> The consensus today is that both are associated with childhood myopia but that parental history plays a far more important role.<sup>21</sup> Nonetheless, clinical trials to evaluate myopia treatment that decreases the negative influence of near work have been reported recently.<sup>24, 25</sup> A topical pharmaceutical agent—pirenzepine—that would retard the abnormal growth of the eye that occurs in myopic children is under clinical evaluation in the US and Asia.

Reports of the prevalence of refractive astigmatism in childhood vary, with some estimates as high as 45% of children having  $\geq 1.00$ DC. These high prevalence estimates come from clinically based samples. When the data are more population based,<sup>8, 26, 27</sup> the expected prevalence is more likely under 10%.

### **Amblyopia**

With a prevalence of 1-5%, amblyopia is the most common cause of monocular visual impairment in both children and young and middle-aged adults. The response to treatment is best when instituted at an early age.<sup>28</sup> Amblyopia affects some six million Americans with significant vision loss and is the leading cause of monocular vision loss in adults aged 20-70 years. Amblyopes are at 16 times greater risk for blindness of the **good** eye.<sup>29</sup> Amblyopia is generally a preventable condition, and the therapy for amblyopia has been reported to be highly cost-effective.<sup>30</sup>

### **Strabismus**

Strabismus has a prevalence of 3-4%. Smoking, alcohol use, and drug use during pregnancy have been associated with a higher incidence of strabismus.<sup>31</sup> Strabismus can lead to amblyopia. In addition, strabismus has many nonvisual effects. Strabismic patients have reported being ridiculed about the strabismus (46-53%), feeling that the strabismus is a cosmetic problem 54-72%, and having a poor self-image (51-77%).<sup>32-34</sup> Strabismic patients have reported that the strabismus interfered with school (52%), work (48%), lifestyle (50%), sports (40%), and job choice (38%).<sup>35</sup> Furthermore, strabismus has been reported to be a career limitation for women seeking management positions.<sup>36</sup> Binocular vision problems can also decrease visual function.<sup>37</sup>

### **Draft Protocol**

We would measure visual acuity, binocular visual function, and refractive error in children every year from age six months to 24 years in order to determine the environmental factors that may impact vision. The protocol would require less than one hour for each child with 30 minutes of "down time" during that hour while the child's pupils dilated. It would require the instillation of 2-3 topical eye drops, which we have done routinely in children aged 3 months to 14 years without incident. As many as 5-7 children could be tested together as a group in an hour or so.

#### **Visual acuity**

Visual acuity is the most appropriate method to detect amblyopia. We will use the most sophisticated method of visual acuity measurement that each child is capable of conducting. At each visit, we will measure the visual acuity of each eye with no correction or with the child's own visual correction in place, if worn to the visit.

- With habitual correction, each eye tested separately:
- Bailey-Lovie About five years and beyond
- HOTV About two to five years
- Teller acuity cards About birth to two years

#### **Binocular vision**

Strabismus is a leading risk factor for strabismus. We will check for strabismus in children using a cover test with prism neutralization while the child looks at a target 6 m and 33 cm away. If a cover test is not possible, we will measure angles kappa and Hirschberg with prism neutralization. We will record the constancy, laterality, and amount of the deviation in primary gaze.

- Cover test at 6 m and 33 cm Two years and beyond
- Angles kappa and Hirschberg Birth to two years
- Stereoacuity Three years and beyond

#### **Refractive error**

Several types of refractive error, especially hyperopia and anisometropia, are risk factors for amblyopia. Cycloplegia yields the most repeatable and accurate measurement of refractive error, especially in young children. Retinoscopy can be conducted in most children, even as young as six months of age.

- Cycloplegic retinoscopy All ages

Subjective refraction

Six years and beyond

**Survey**

Several risk factors for refractive error, strabismus, and amblyopia that can be obtained through surveys have been identified. Pertinent questions not asked during the National Children's Study will be identified and surveyed specifically for this purpose

- Family history of eye turns
- Family history of smoking
- Family history of alcohol
- Socioeconomic status

**Examinations**

Refractive error changes very rapidly as the eye grows through the first two years of life, and it may continue to change through early adult-hood. Examinations should be conducted annually, beginning at six months of age.

- At 6 months and every year thereafter

**Referrals for further, complete eye care**

- |                 |   |
|-----------------|---|
| • Visual acuity | 20/30 or worse  |
| • Tropia        | All   |
| • Phoria        | Greater than 10 <sup>Δ</sup>  |
| • Myopia        | All   |
| • Hyperopia     | Greater than +3.50 D  |
| • Astigmatism   | Greater than -3.00 DC before age 3<br>Greater than -1.00 DC after age 3 |
| • Anisometropia | Greater than 1.00 D difference between the eyes                         |

Figure 1. Changing distribution of refractive error in infants and children, due to emmetropization.

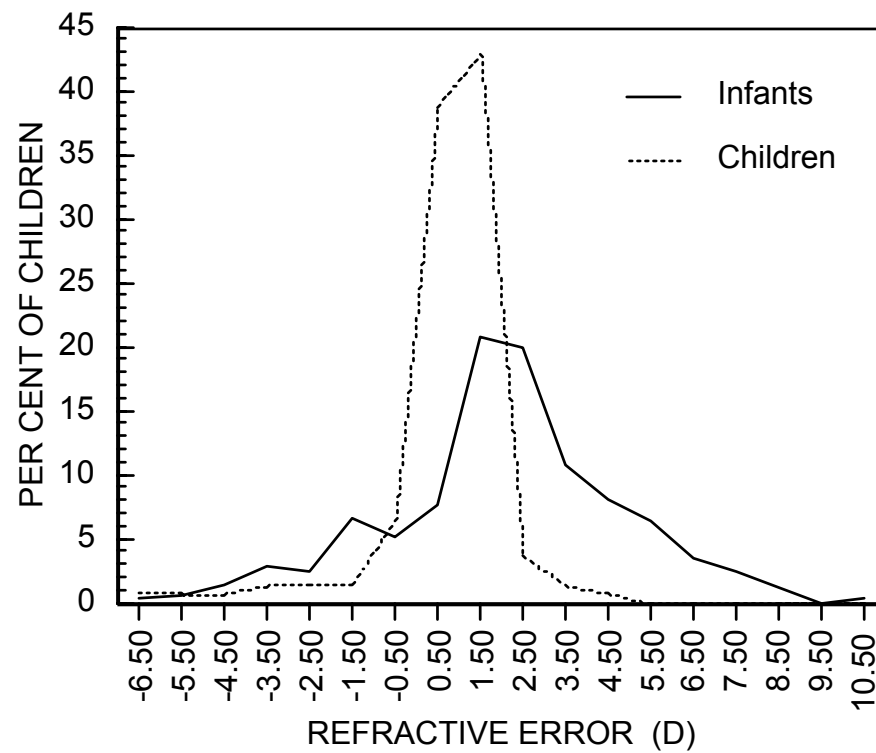
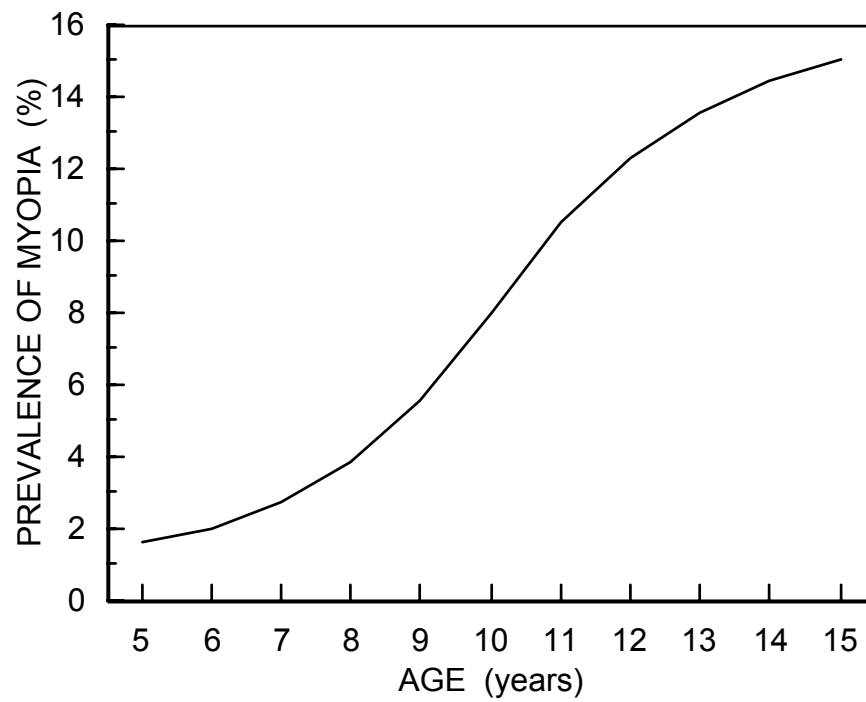


Figure 2. Increasing prevalence of myopia with age during the school years.



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